1.1.1.1.1.9 Chapter

10

10. Electronic Search Patterns

While the mission observer's role seems to be concentrated in visual searches, his contributions in electronic searches are no less important. The observer's understanding of electronic search techniques, and his ability to assist the pilot can substantially increase both search effectiveness and the timeliness of recovering accident victims.

Electronic searches are most efficient when the equipment, the environment and the terrain are ideal. This includes flat, level terrain, few natural or man-made obstructions and properly functioning equipment. These ideals seldom exist. Therefore, the effectiveness of electronic searches depends heavily on the experience and expertise of the search crews employing them. Through practice, you will understand the difficulties caused by ELT signals reflected from obstructions, the adaptability of electronic search methods to overall conditions, and the monitoring of radio equipment to ensure proper operation.

The use of electronic equipment in locating missing aircraft or survivors is an alternative to visual searches. The primary equipment in these type searches is an emergency locator transmitter (ELT) and ELT reception device. Once it has been established that an ELT was on board the missing aircraft, a combined track route and ELT search can be launched. The success of this type of search depends on the life of the battery of the ELT, the survivability of the entire ELT unit and whether the unit was activated or not. There is always the possibility ELT equipment may be inoperable due to the effects of the crash. Since an ELT aboard an aircraft does not guarantee that it can be located with an electronic search, both an electronic search and a concentrated general search should be organized at the same time.

10.1 ELT and SARSAT

Electronic equipment and procedures are used in general searches to focus the search and rescue effort in a specific area, or as an alternative to visual searches when visibility is reduced by weather or other atmospheric conditions. Equipment used in these searches may include a battery-powered emergency locator transmitter (ELT) aboard the incident aircraft, search and rescue satellites, and an ELT receiver aboard the search aircraft.

The Federal Aviation Administration (FAA) requires most US-registered general aviation aircraft to have operable ELTs installed, which activate automatically when sensing acceleration forces during an accident. An active ELT transmits a continuous radio signal on a specific frequency until it’s either deactivated or its battery discharges.

In a cooperative effort among several nations, search and rescue-dedicated satellites (SARSATs) orbit the earth and alert to ELT transmissions. Upon receiving an ELT signal, the SARSAT derives the approximate lat/long coordinates of the ELT position, and the coordinates are passed through rescue channels to the incident commander. Aboard the search aircraft, a radio receives the ELT signal, and converts it into an audible tone and a signal that's processed by the direction finder. The direction finder (DF) provides the crew with relative direction, or bearing, to the transmitter.

Upon receiving SARSAT coordinates, or determining that an ELT was aboard a missing aircraft, the IC/MC may launch a combined ELT and visual route search. Search success may depend upon several factors. The fact that an ELT was aboard a missing aircraft does not necessarily guarantee that electronic search procedures will locate it because the unit may have been inoperative or the batteries totally discharged. Also, the crash forces may have been insufficient to activate the ELT or so severe that it was damaged. Incident commanders may attempt to maximize the search effort by conducting an electronic search and a general visual search simultaneously when weather and other circumstances permit.

10.2 Track crawl and parallel track

Before you can use any technique to locate an ELT, you must first be able to pick it up on your radio. The track line (route) pattern (Figure 10-1) or the parallel track (Figure 10-2) search patterns are the most effective at this stage. The aircraft conducting an electronic search will normally begin the search at or near the last known point (LKP), and fly the search pattern at altitudes from 5,000 to 10,000 feet above the terrain, if possible. At this altitude, the aircraft can usually intercept the ELT signal and may be able to see the crash site. At the maximum electronic search altitude, which is much higher than 10,000 feet, chances are slim that one can recognize or distinguish a light plane crash site. Maximum track spacing should be used initially to provide a rapid sweep of the probability area. Successive sweeps should have a track spacing one-half the size of the initial spacing. For example, if the track spacing is 60 nautical miles during the initial sweep of the area, then the track spacing for the second sweep of the area should be 30 nautical miles. A third sweep of the area, if needed, should have track spacing of 15 nautical miles. This method of gauging the track spacing applies to both track line (route) and the parallel track. These procedures may by repeated until the missing aircraft or survivors are located, or until it is presumed that the batteries of the ELT have been exhausted.

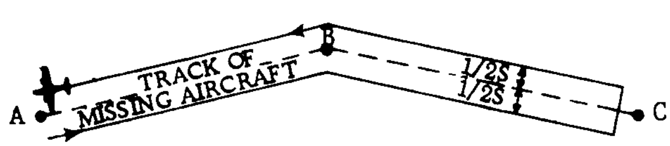

Figure 10-1

In mountainous terrain the initial search pattern should be arranged to cross ridgelines at right angles, if at all possible. The search coverage of the area should be at right angles to the first coverage tracks to compensate for blockage of the ELT signal due to the shape of the terrain.

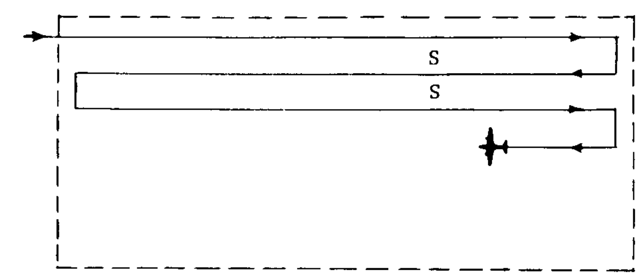

Figure 10-2

Once the searchers are in a position to receive the ELT signal, they may use one of several methods to locate the transmitter and the accident scene. Homing is the simplest and most common method, but it requires special equipment that is not installed in all search airplanes. The metered search also requires special equipment that may not always be available. The signal-null and aural search methods are used less frequently, but they may be used aboard any airplane equipped with a radio receiver. Each requires only the crew's ability to hear the ELT tone through the search aircraft's radio or intercom.

10.3 Homing

Homing is an electronic search method that uses a direction finder to track the ELT signal to its source. With the direction finder (DF) set to the ELT operating frequency (121.5 MHz; 243.0 MHz for military aircraft), the pilot will fly the aircraft to the transmitter by keeping the left/right needle centered. ELTs may transmit on either 121.5 MHz VHF, 243.0 MHz UHF, or both frequencies simultaneously. These emergency frequencies are *usually* the ones monitored during a search, but homing procedures can be used on any radio frequency to which *both* a transmitter and DF receiver can be tuned.

In order to for the DF part of the ELT receiver to function, the “Alarm” toggle switch must be in the ‘down’ position. Also, the observer must maintain the DF unit’s “signal strength” needle centered with the signal strength control knob.

In the following scenario, the search objective is an active ELT at a crash site. The first step is to tune the receiver to the ELT frequency and listen for the warbling tone of the ELT signal. Next you have to determine the direction to the ELT. When you fly directly toward a signal, the left/right needle remains centered. However, when you head directly *away* from the signal, the needle also centers. A simple, quick maneuver is used to determine if you are going toward or away from the signal.

Starting with the left/right needle centered, the pilot turns the aircraft in either direction, so that the needle moves away from center. If he turns left, and the needle deflects to the right, the ELT is in front. If the pilot turns back to the right to center the needle, then maintains the needle in the center, you will eventually fly to the ELT.

If, in the verification turn, the pilot turns left and the needle swings to the extreme left, then the ELT is behind you. Continue the left turn until the needle returns to the center. You are now heading toward the ELT, and as long as the pilot maintains the needle in the center, you will fly to the ELT.

Flying toward the ELT and maintaining the needle in the center of the indicator *is* the actual homing process. If the needle starts to drift left of center, steer slightly left to bring the needle back to the center. If it starts to drift right, turn slightly back to the right. Once you have completed the direction-verification turn, you will not need large steering corrections to keep the needle in the center.

When passing over the ELT or transmission source, the left/right needle will indicate a *strong* crossover pattern. The needle will make a distinct left-to-right or right-to-left movement and then return to the center. This crossover movement is *not* a mere fluctuation; the needle swings fully, from one side of the indicator to the other and then returns to the center.

During homing you may encounter situations where the needle *suddenly* drifts to one side then returns to center. If the heading has been steady, and the needle previously centered, such a fluctuation may have been caused by a signal from a second transmitter. Another aircraft nearby can also cause momentary needle fluctuations that you might not hear, but the needle in the DF will react to it. Signal reflections from objects or high terrain can also cause needle fluctuations at low altitudes in mountainous terrain or near metropolitan areas.

10.4 Wing shadow method (signal null)

The signal null or wing shadow method is based on the assumption that the metal skin of the search aircraft's wing and fuselage will block incoming ELT signals from the receiving antenna during steep-banked turns. The observer can make simple estimates of the magnetic bearing to the transmitter by checking the aircraft heading when the signal is blocked.

Once the search aircraft completes several signal-blocking turns in different sectors of the search area, the observer can establish the approximate location of the ELT by drawing magnetic bearings, or "null vectors," on the sectional chart. The ELT and accident scene will be at or near the intersection of the null vectors.

To use the null method, the search aircraft must be made of metal so that the ELT signal can be blocked. Aircraft having fabric or plywood covered wings are not suitable for the null search method, because the wings may not block the signal well enough for the method to work properly. You must also know the location of the receiving antenna (i.e., on the bottom or the top of the aircraft).

10.4.1 Procedures

First, verify the receiver is tuned to the proper ELT frequency and that you can hear the warbling tone. Mark your position on the sectional chart, preferably over a small but significant feature. Then the pilot will make a 360°, <u>steeply-banked</u> turn to allow you to determine the signal's direction. As the airplane turns, the ELT tone will break, or null, at the point when the aircraft wing and skin come between the transmitter and the antenna. For a brief instant you will not hear the tone. The absence of the audible tone is referred to as the *null*.

On aircraft with the antenna installed on the underside, the wing inside the turn ("down" wing) of the banking airplane, points toward the ELT when the tone nulls. On aircraft with the antenna installed on the top, the wing on the outside of the turn ("up" wing) points toward the ELT when the null is heard.

To estimate the magnetic bearing from the search airplane to the ELT, the observer makes simple calculations. In high-wing airplanes, if you're turning left,

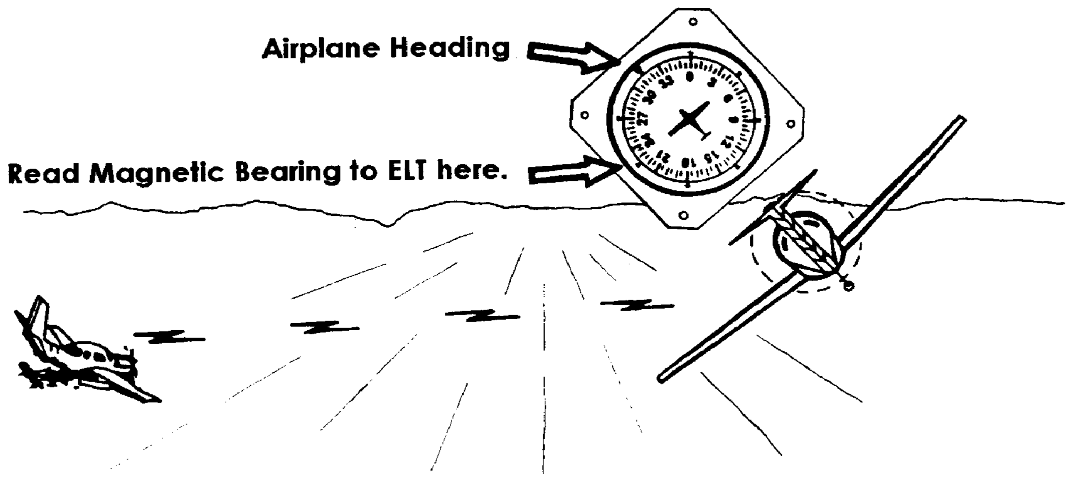

Figure 10-3

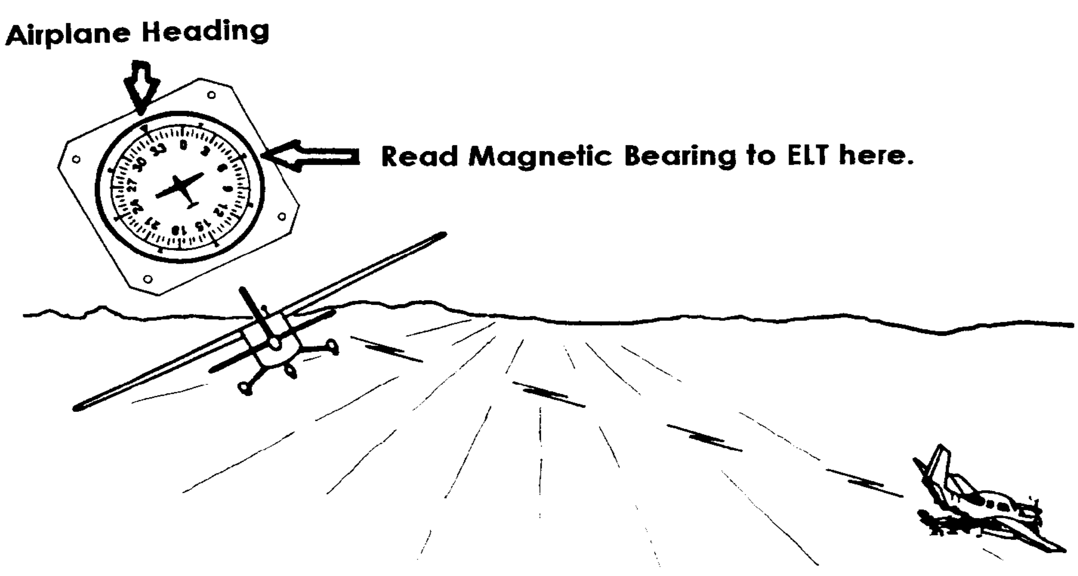

Figure 10-4

add 90° to the aircraft heading when you hear the tone null. If you're turning right, subtract 90° from the heading at the instant you hear the tone null. In low-wing airplanes, when you're turning left, subtract 90° from the aircraft heading, and when making right turns, add 90° to aircraft heading.

You may find it simpler to make these bearing estimates using the face of the heading indicator. Imagine an aircraft silhouette on the face of the search airplane's heading indicator. The silhouette's nose points up toward the twelve o'clock position, and the tail points toward the bottom or six o'clock position. The left wing points left to nine o'clock, and the right wing points to three o'clock. Some heading indicators actually have this silhouette painted on the instrument face, as shown in Figures 9-3 and 9-4. This imaginary plane always mimics whatever the search airplane is really doing.

Upon hearing the null, the observer should quickly look at the heading indicator. If the search aircraft is a low-wing aircraft, like the *Cherokee,* look for the number adjacent to the imaginary aircraft's low wing, as shown in Figure 10-3. If the search plane is a high-wing, like the Cessna 172, look for the number adjacent to the imaginary plane's high wing, as shown in Figure 10-4. That number is the magnetic bearing from the search aircraft's present position to the ELT transmitter.

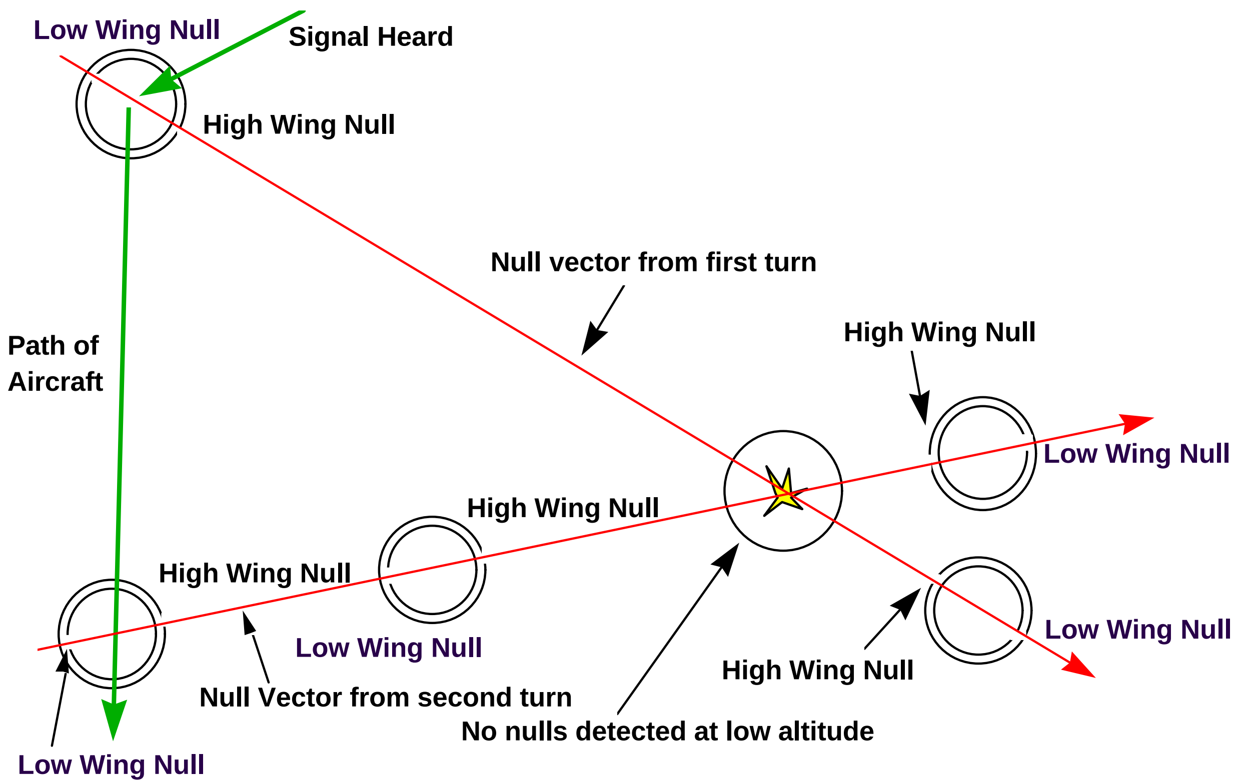

Figure 10-5

Regardless of the method used to determine the ELT's magnetic bearing, the next step is to convert that magnetic bearing to a true bearing by adding or subtracting the published magnetic variation for that area. Then draw a line on your chart from the search aircraft's known position in the direction of the calculated true bearing. You now have one null vector, or line of position, to the ELT. The ELT is somewhere along that line, but it isn't possible to tell exactly where. To narrow the focus, simply repeat the process starting from another known position over a different geographical point. Don't pick your next geographical point near to or along the initial null vector. The accuracy of this technique improves if you select geographic points well away from each other. If the points are well separated, the null vector lines will intersect at a larger angle, and the position will be more accurate. Figure 10-5 shows an entire null signal search. Notice that several fixes may be taken before deciding the limits for the subsequent visual search. Finally, fly to the area indicated by the null-vector intersection and attempt to pinpoint the ELT.

Upon reaching the area, the pilot can descend to a lower altitude and execute similar steep turns. If you are very close to the ELT, you can expect to hear no null, due to the higher signal strength near the transmitter and the inability of the wing to block the signal. When an ELT tone is continuous through a full 360° turn, the ELT transmission is very likely in the area beneath the search aircraft. You can then chart the probable location of the missing aircraft or transmitter to within a small area.

If descending to a lower altitude brings the aircraft within 1,000-2,000 feet above the terrain, you should discontinue null procedures. Instead, you should descend to an appropriate lower altitude and begin a visual search.

10.4.2 Special Considerations in Signal Null Searches

Four special considerations must be made prior to and during signal null searches. The most important is crew ability. Maintaining altitude throughout steep turns requires skill and extensive practice. Some aircraft may stall and then spin if over-controlled in poorly executed turns. This can result in a great loss of altitude, structural damage to the airplane during recovery, or collision with the ground. The pilot must be skilled in executing steep-banked turns.

Second is positive knowledge by the search crew of its actual position when the null is heard. By constantly monitoring the search aircraft's position in the turn, you can plot each null vector more precisely.

Third, the search crew must know what to do if the signal is lost during a search. If you lose the signal while trying to pinpoint the ELT's location, you can return to the position and altitude of the last contact with the tone. The observer's chart is a useful record of each position where successful procedures were performed.

Finally, as you approach the suspected ELT location, be more alert for other aircraft. Since a search is likely to include more than just your airplane, you should expect the ELT location to become a point of convergence for all aircraft involved in the search. Once you establish the general location of the downed aircraft, you *must* approach the area with caution. A midair collision can easily result if the entire crew's attention is focused on the accident scene while other aircraft approach the same area.

10.5 Aural (or hearing) search

The aural or hearing search technique is based on an assumption that an ELT's area of apparent equal signal strength is circular. Throughout this procedure the observer *must not* adjust the receiver volume. A constant volume helps assure that "signal heard" and "signal fade" positions will remain consistent.

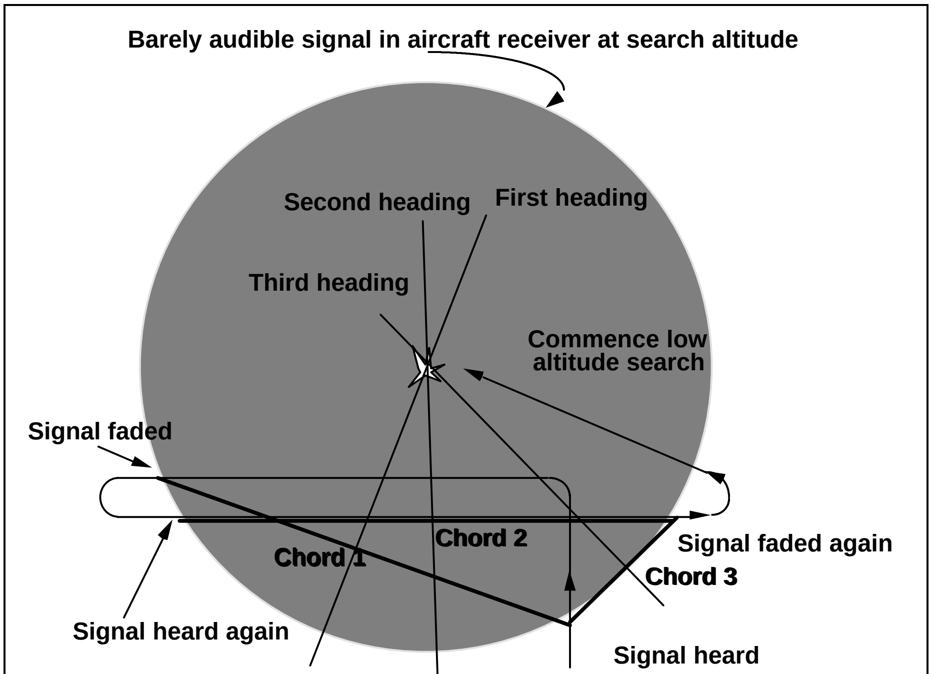

Figure 10-6

Also, once you begin the procedure, make all turns in the same direction as the first turn if terrain permits. The observer begins the aural search by plotting the search plane's position when the ELT tone is first heard. The pilot continues flying in the same direction for a short distance, then turns 90° left or right and proceeds until the tone volume fades. The observer charts the aircraft position where the tone volume fades. The pilot then reverses aircraft direction, and the observer again marks on the map the positions where the signal is heard again and where it fades. If the radio volume has not been adjusted, the "signal fades" and "signal heard" positions should be approximately equidistant from the ELT. To determine the approximate location of the ELT, the observer draws lines to connect each set of "signal heard" and "signal fade" positions.

At the midpoint of each of these new lines, or chord lines, the observer constructs a bisector, a perpendicular line that points toward the center of the search area. The point where these bisectors intersect is the approximate location of the ELT. Figure 10-6 illustrates the connection of the signal heard and signal fade positions with the chord lines, the perpendicular bisectors' converging toward the center of the search area, and the intersection over the probable location of the ELT. Once the observer establishes the approximate location of the missing aircraft, the pilot flies to that location and the crew begins a low-altitude visual search.

The crew must remember that locating the ELT in this fashion is not precise. The determination is approximate because the area of equal signal strength on which this procedure is based is seldom, if ever, perfectly circular. The perpendicular bisectors rarely intersect directly over the objective. However, a low-altitude visual search of the general area can help compensate for lack of precise location.

This pattern is based on the assumption that the area of equal beacon signal strength is circular. When using this procedure, which does not require a special antenna, the search aircraft is flown in a "boxing in" pattern. The observer begins the aural search method by plotting the search aircraft's position as soon as the ELT signal is heard. The pilot continues on the same course for a short distance, then turns 90 degrees either to the left or right and proceeds until the signal fades.

Next the observer charts the positions where the signal fades. The pilot turns the aircraft 180 degrees and once again the observer marks on the map the positions where the signal is heard and where it fades. During this procedure the observer should not adjust the receiver volume. A standard volume ensures that the "signal heard" and "signal fade" positions will remain constant.

To establish the approximate position of the ELT unit, the observer draws chord lines between each set of "signal heard" and "signal fade" positions. Then the observer draws perpendicular bisectors on each chord. The bisectors are drawn from the mid-point of each chord toward the center of the search area. The point where the perpendicular bisectors meet, or intersect, is the approximate location of the ELT unit. After the observer establishes the approximate location where the missing aircraft may be found, the pilot flies to that location and begins a low-altitude visual search pattern.

The observer should remember that the calculations on pinpointing the location of the ELT unit are approximate, not exact. The calculations are called approximate because the area of equal signal strength on which this procedure is based is seldom, if ever, circular. Thus the perpendicular bisectors seldom intersect directly over the target. However, low-altitude visual searches over the general area, pinpointed with the aural search method, compensate for the lack of exact target location.

10.6 Metered search

To employ the metered search method, the observer uses a signal strength meter to monitor the ELT signal. Referring to Figure 10-7, the circled numbers represent the sequence of events and numbers plotted along the track are hypothetical signal meter readings, with higher numbers representing weaker signals and lower numbers representing stronger signals.

Once the aircraft enters the search area, the observer plots two positions of equal meter strength. For example, as the aircraft enters the search area, assume the signal strength measures 8.0. The observer records the signal strength and notes the search aircraft's position. As the search aircraft continues, the signal strength increases and then begins to diminish, or weaken. When the signal registers 8.0 again on the meter, the observer plots the midpoint between these two points, while the pilot makes a 180-degree turn and flies toward the midpoint. Upon reaching the midpoint, the pilot makes a 90-degree turn to the right or left. If the signal strength begins to fade, the search aircraft is heading in the wrong direction. The pilot corrects the direction by making a 180-degree turn. This change in heading now carries the search aircraft toward the ELT signal. As the aircraft is flying on a heading toward the ELT signal, the observer again plots

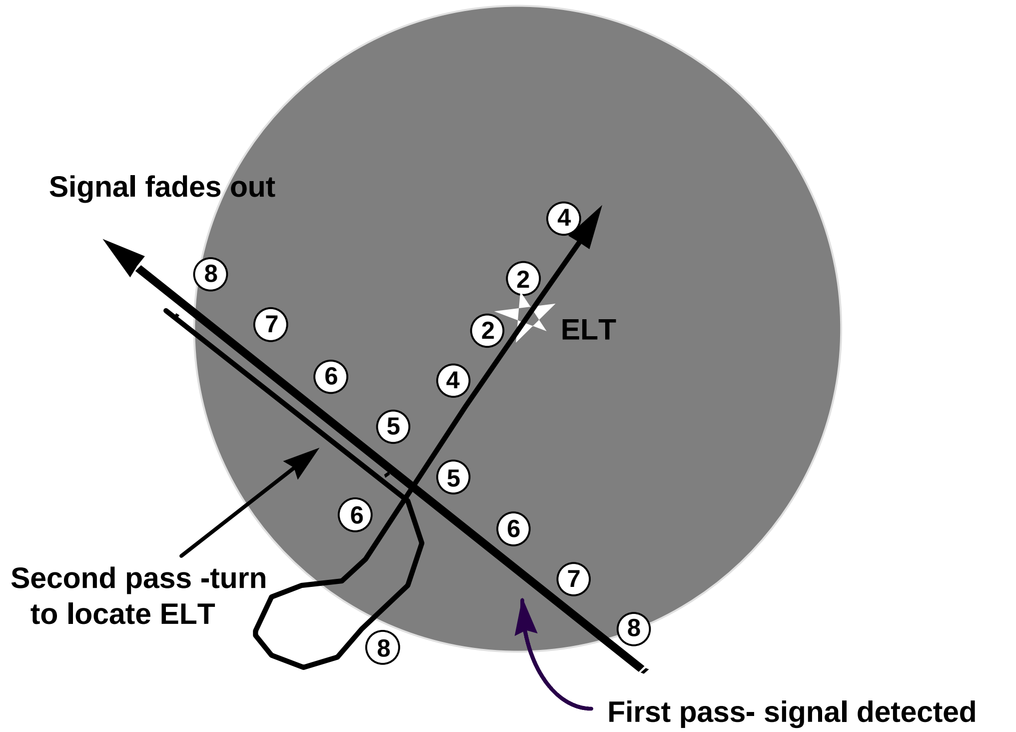

Figure 10-7

two points of equal meter reading. As the second point of equal strength is passed, the pilot makes a 180-degree turn and descends to the area that emitted the strongest signal. Upon reaching this area, the search crew begins a visual search at an appropriate altitude. The numbers plotted along the search track are signal meter readings with the higher numbers representing the weaker signals and the lower numbers indicating the stronger signals. When search crews properly use this method they can quickly locate the ELT unit and downed aircraft.

10.7 Night and IFR electronic search

Each of the preceding electronic search methods has certain limitations that effect its usefulness during darkness or in instrument conditions. In this discussion, “instrument conditions” means weather conditions that compel the pilot and crew to operate and navigate the aircraft by referencing onboard instruments and navigational radios. Never conduct searches requiring steep turns in instrument conditions!

Darkness and poor weather reduces your ability to precisely determine your position, and that impacts the effectiveness of all electronic search procedures. The accuracy of the null vectors, "signal heard" and "signal fade" points, and points of equal meter signal strength all depend on your ability to accurately fix your position over the ground. Even when you've successfully homed to an ELT, unless you can accurately determine your position, you've only succeeded in narrowing the general area for ground search efforts that follow. GPS (or LORAN) and VOR equipment help regain some of this lost capability.

Other considerations relate to safety and qualifications. The FAA requires that, for flight in instrument conditions, both pilot and airplane must have special certification. Instrument flight imposes a higher workload on the crew and demands a higher level of training, especially for the pilot. As discussed earlier, the ability to fly steep-banked turns and other maneuvers without losing altitude is demanding for even the most proficient pilot. Trying to conduct these maneuvers in darkness or while flying solely by referencing the flight instruments is not allowed. The pilot could easily get vertigo and lose control of the aircraft. If the search is conducted in instrument conditions, DF homing with the use of accurate navigational aids is the only method that may be allowed.

10.8 Signal Reflection and Interference

Radio signals reflect off terrain and manmade objects, and this can be a problem for search and rescue teams. In an electronic search, it is vitally important to know if the equipment is reacting to reflected signals and what you can do to overcome the problem. Although tracking a signal is the best means of locating an ELT, actually isolating the signal can occasionally become a problem. The following scenario illustrates one approach to a signal reflection problem.

After receiving a briefing, the pilot and observer check their aircraft and take off. Upon reaching the designated search area, the observer picks up an ELT signal. Using the DF, the search crew follows the signal for 10 minutes in a northerly direction. The observer later notes that keeping the left/right needle centered requires a 60° turn. This sudden turn causes the observer to conclude the signal is being reflected for two reasons. First, it is highly unlikely that the aircraft wreckage moved, causing a change in direction. Second, if sufficient crosswind was present to cause the change, it should have been noticeable earlier. Since the wreck didn't move, and there is no significant crosswind, the observer concluded that the apparent course problem was caused by reflected signals.

The observer can have the pilot climb to a higher altitude to eliminate or minimize the effects of reflected signals. Reflected signals are usually weaker than those coming directly from the transmitter, so climbing can help the stronger direct signals come through. Also, depending on the terrain, a higher altitude may result in more time available for the crew to detect the transmitter. Figure 10-8 shows how climbing to a higher altitude can help overcome the problem of signals blocked by terrain.

The specific pattern used during an electronic search over mountainous or hilly terrain can help compensate for blocked signals and reflections. You should alternate flying patterns parallel to valleys or ridges, and flying the patterns at perpendicular angles. The following example demonstrates this technique.

The crew receives the briefing and flies to its assigned area. The rectangular-shaped area is divided by a range of mountains extending north to south. The search crew elects to fly the initial pattern over the area east to west, then returns west to east. After making five uneventful passes over the mountains at 10,000 feet above the terrain, the observer hears the ELT on the sixth pass. On subsequent passes the observer hears the signal for three minutes during each pass and plots each area where the signal was audible. To further define the ELT position, the observer requests the pilot fly a course perpendicular to the previous

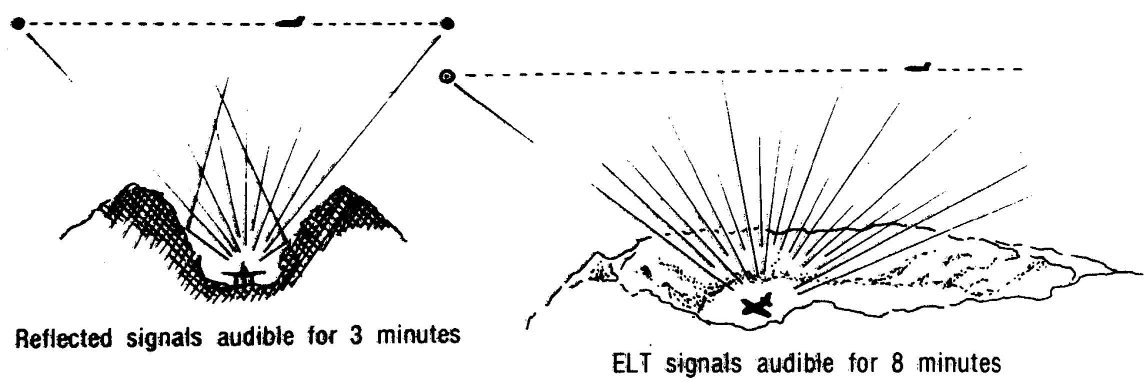

Figure 10-8

headings. This new course takes the aircraft parallel to the mountain range. On the third pass near the mountains, the observer hears the ELT again, this time for eight minutes. After another pass over the area to verify the eight-minute reception, the observer plots a small area on the map as a likely location of the ELT. The observer concludes that terrain is a major factor in causing the signal to be audible for short periods of time. The missing aircraft has possibly crashed in a ravine or narrow canyon that permits transmission of the ELT signals to a limited area above the crash site.

Descent to a lower altitude helps confirm the observer's speculation. The missing aircraft has crashed in a long, narrow ravine running parallel to the north-south mountain range. The mountain walls around the aircraft significantly limit transmission of the signals in an east-west direction, so the observer is only able to hear the signal for three minutes while searching in an east-to-west or west-to-east direction. When the aircraft track is parallel to the mountain range, the observer hears the signal for eight minutes. When the crew flies along the length of the ravine where the plane crashed, they are able to maintain signal contact for a longer time. Figure 10-8 also illustrates this effect.

When faced with strange circumstances like the two examples described above, try to visualize the situation and search for a logical explanation. Consider every factor that could cause the problem, including equipment reliability, terrain, other sources of interference like the electrical fields of high-tension power transmission lines, and the direction finding procedures themselves. If one method of electronic search doesn't yield the results you expect, try another method. Don’t become so involved with one method that you can't switch to a more suitable method if the situation demands.

Electronic searches are normally only as effective as the crews employing them. They work best when the equipment, environment, and terrain are ideal. Unfortunately, such ideal conditions seldom exist. Crews must practice search methods to better understand difficulties caused by various conditions. This will help you be prepared to deal with less than ideal conditions. Whenever you are faced with strange circumstances, you should seek the most logical explanation. In looking at the problem, always consider every factor that could possibly cause the situation. Consider the equipment reliability, the terrain and the DF procedures. If one method of electronic search doesn't yield the type of results you expect, try another method. Don't become so involved in one method that you can't adopt a more suitable method if the situation demands it.